Programming in Java – Classes

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Agenda

Classes

instance variables, methods, ...

Constructors

default, multiple, the keyword “this”, …

Methods

Referential equality

Static members

Classes

A sample class

```
class Television {
    String model;
    boolean on;
    int channel;
    int volume;
}
```

Definition of a class with four instance variables, fields

Creation of a new object of class Television
new + constructor

```
new Television();
Television tv;
tv = new Television();
```

Declaration of a variable of type Television

Creation and assignment of an object of class Television. The variable tv holds a reference to the new object.

```
tv.model = "LG5464VX";
```

Instance variables are accessed using the dot notation

Classes

Classes are used to define new types. Once a class is defined, we can then create new objects of that class. These objects are instances of that class, and that class is the type of these objects.

As the words class and type can be used interchangeably, so object and instance can be used interchangeably too.

~~Instance~~ methods define how other entities can interact with the objects of that class.

~~Instance~~ variables differentiate the behavior of different instances of the same class.

A class is composed of

- ~~instance~~ methods, that define the operations that can be performed on its instances
- ~~instance~~ variables, that define the data that is associated to an object

Methods and instance variables are collectively known as members

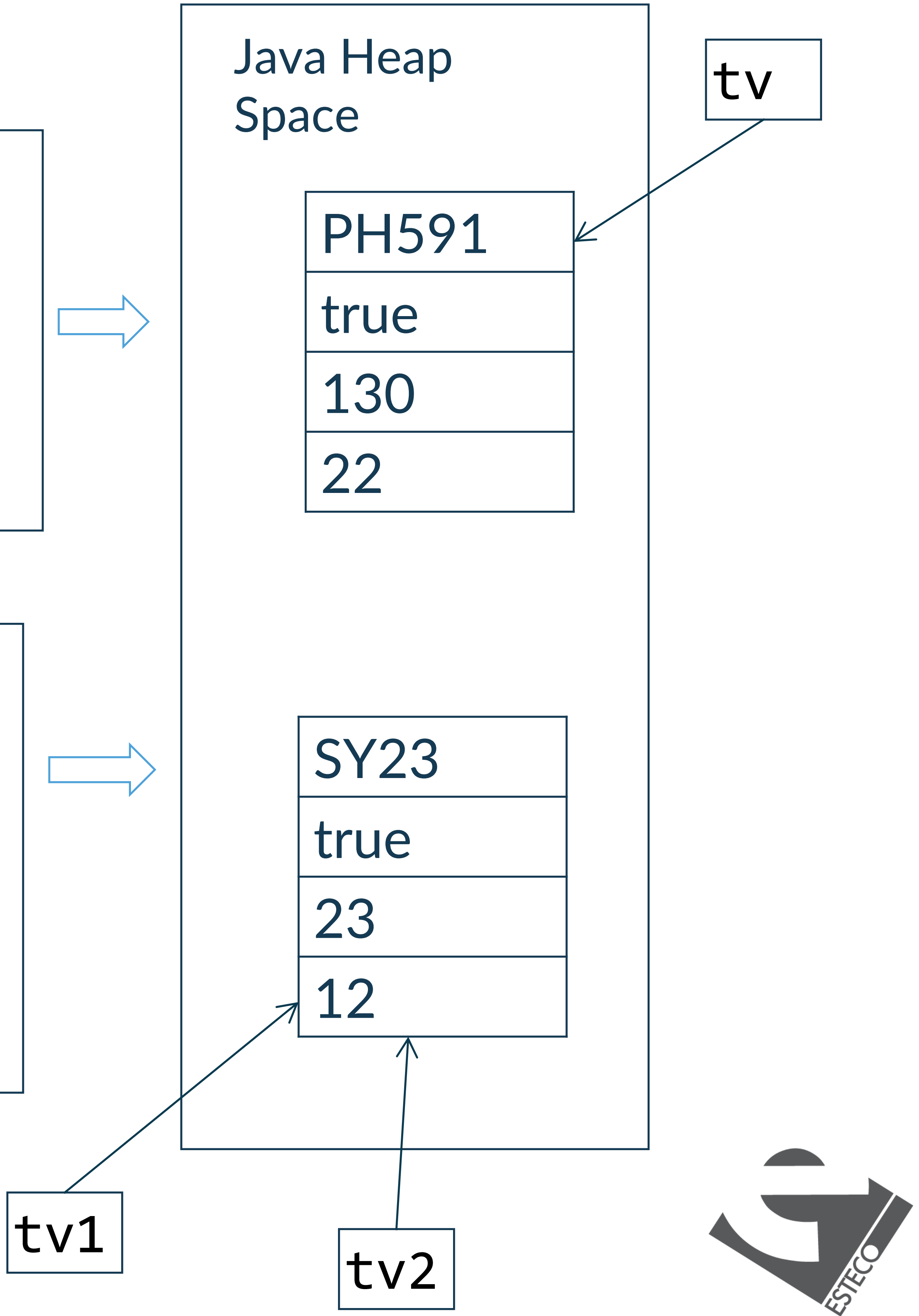
More on classes and references

When we create an object, by using the new operator, we allocate the memory to hold the instance variables of this new object

```
var tv = new Television();
tv.model = "PH591";
tv.on = true;
tv.channel = 130;
tv.volume = 22;
```

Two, or more, references to the same object point to the same memory location.

```
Television tv1 = new Television();
Television tv2 = tv1;
tv1.model = "SY23";
tv1.on = true;
tv2.channel = 23;
tv2.volume = 12;
```



Java Heap Space

tv

PH591
true
130
22

SY23
true
23
12

tv1

tv2

Objects vs. primitive types or refences vs. values

```java
int i1 = 10;
int i2 = i1; //we copy the value of i1 in i2
i1 = i1 + 1; //now i1 is 11, i2 is still 10
```

Variables of primitive types hold the value represented by the primitive

Variables of object references hold a reference to the object

```java
Television tv1 = new Television();
Television tv2 = tv1;
tv1.model = "SM2192"; //now both tv1 and tv2
                      //model property is “SM2192”
```

No new object creation nor object copy is involved when we copy one reference from one variable to another variable

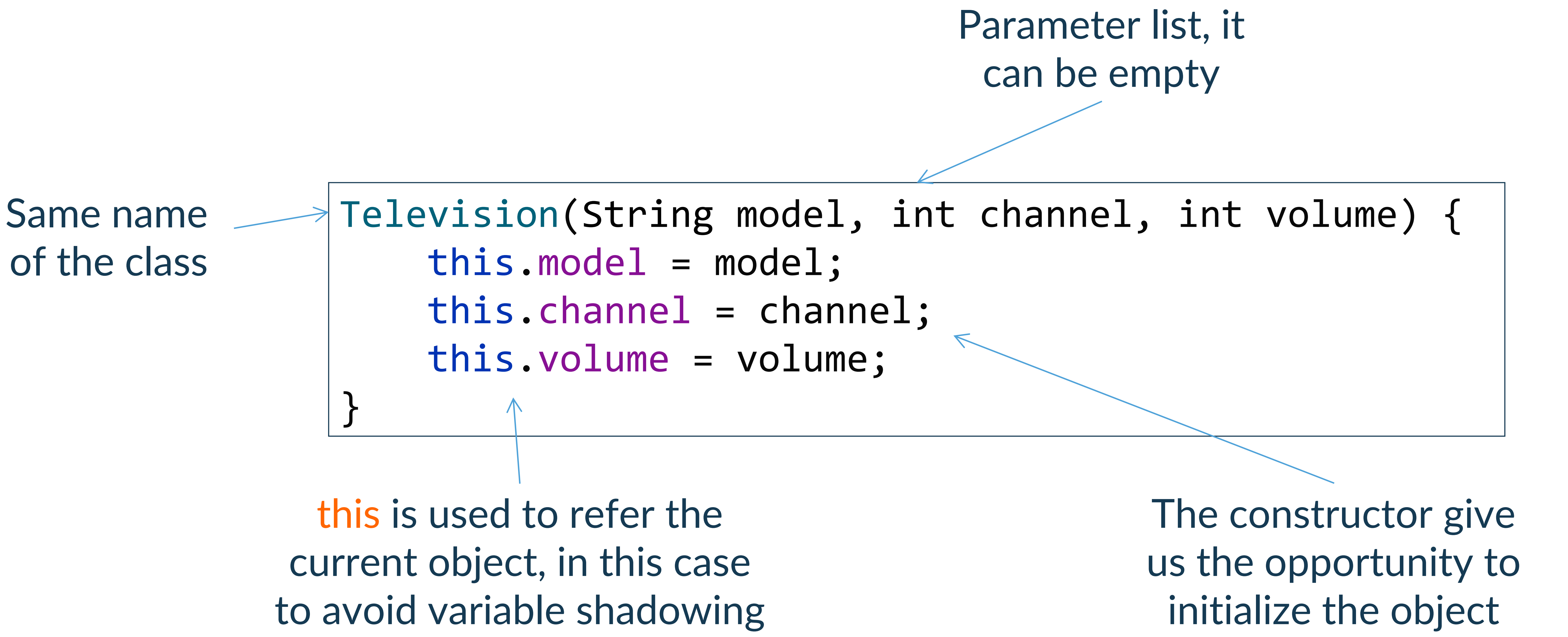
Constructors

Constructors

The creation of an object using the new operator is a two steps operation

1. Java allocates the memory for the object
2. the class constructor is invoked

If we don't define a constructor for a class, Java automatically defines a default constructor



Parameter list, it can be empty

Same name of the class

```
Television(String model, int channel, int volume) {
    this.model = model;
    this.channel = channel;
    this.volume = volume;
}
```

this is used to refer the current object, in this case to avoid variable shadowing

The constructor give us the opportunity to initialize the object

Constructor overloading

Java allows constructor overloading, a class can have multiple constructors, given their parameter lists are different.

The default constructor has an empty parameter list.

Once we define at least one constructor, the default one is no more available

```java
class Television {
    String model;
    boolean on;
    int channel;
    int volume;

    Television(String model, int channel, int volume) {
        this.model = model;
        this.channel = channel;
        this.volume = volume;
    }

    Television(String model) {
        this.model = model;
    }
}
```

Constructor chaining

It is possible to invoke one constructor from another one, using this(), possibly with an argument list.

The call to this() must be the first statement within the constructor.

When this() is executed, the overloaded constructor that matches the parameter list is executed first. Then, if there are any statements inside the original constructor, they are executed.

```
class Television {
    String model;
    boolean on;
    int channel;
    int volume;

    Television(String model, int channel, int volume) {
        this(model);
        this.channel = channel;
        this.volume = volume;
    }

    Television(String model) {
        this.model = model;
    }
}
```

Construction of Strings

```java
//Create a new String object
String a = "Some string";

//Create a new String object
String b = new String(new char[] {'S', 'o', 'm', 'e', ' ', 's', 't', 'r', 'i', 'n', 'g'});

//Create two String objects
String c = new String("Some string");

//Create a new String object
String d = a + b;

//We don’t know, maybe the compiler is doing some optimization
String e = "Some" + " " + "string";
```

Destructors

In Java there are **no** object destructors

Methods

Methods

```
class Television {
    String model;
    boolean on;
    int channel;
    int volume;
}
```

The Television class we have defined is almost useless. Why?

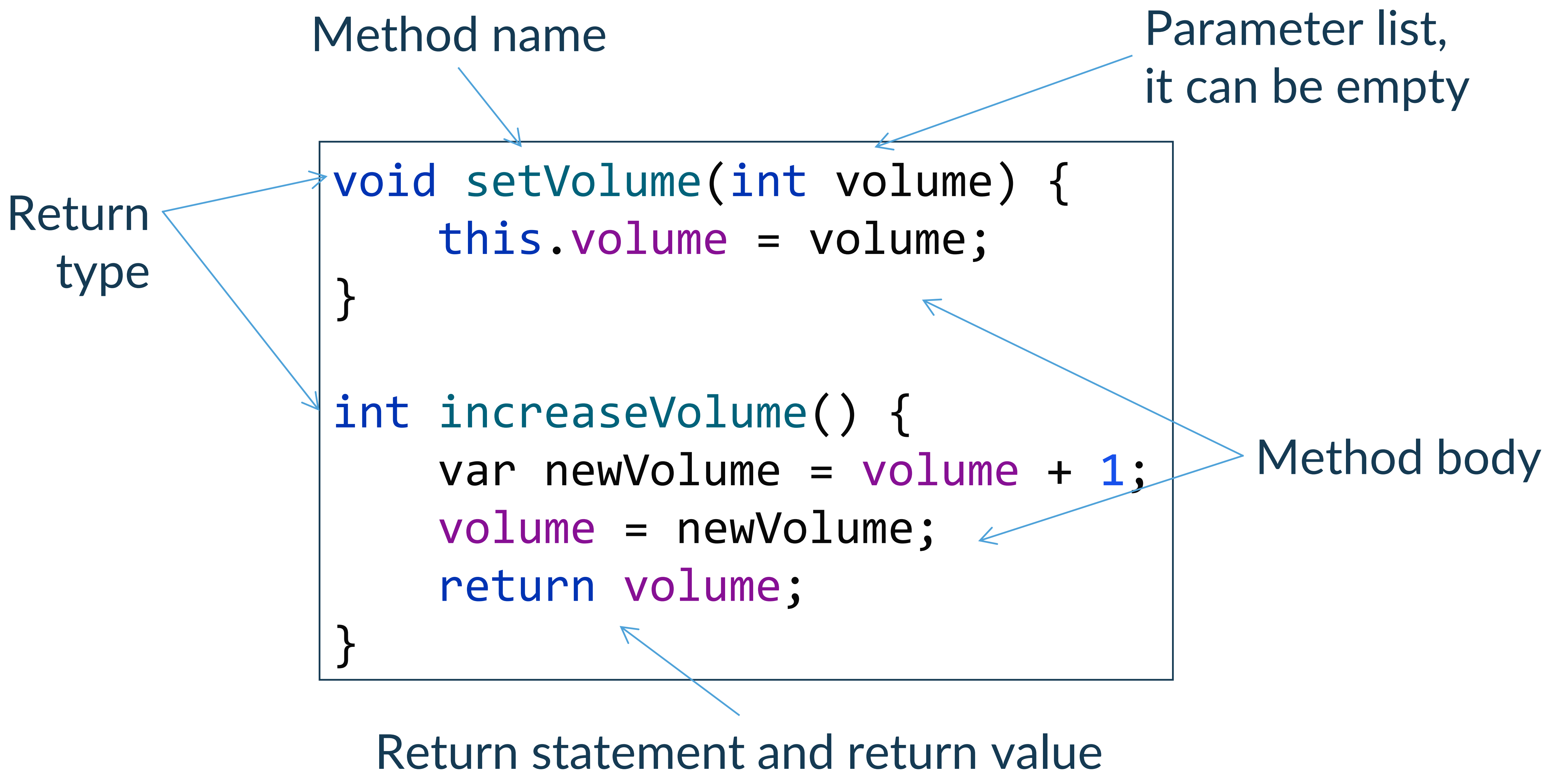
It has no methods, it doesn’t expose any behavior, it is just a data object

Data objects need other classes to operate on their own data, this violates encapsulation and reduces code cohesion

Cohesion is the degree to which the elements inside a module belong together

“the code that changes together, stays together”

Method definition



Method name

Parameter list, it can be empty

Return type

```
void setVolume(int volume) {
    this.volume = volume;
}

int increaseVolume() {
    var newVolume = volume + 1;
    volume = newVolume;
    return volume;
}
```

Method body

Return statement and return value

Method invocation

Similar to instance variables, instance methods are invoked using the dot notation

```java
Television tv = new Television("LG543");
tv.turnOn();
tv.setChannel(23);
tv.increaseVolume(5);
tv.setChannel(80);
tv.turnOff();
```

Method overloading

Like the constructor case, Java allows method overloading, a class can have multiple methods with the same name, if their parameter lists are different.

```
int increaseVolume() {
    return ++volume;
}

int increaseVolume(int delta) {
    return volume += delta;
}
```

Different parameter list

Different return type

```
int increaseVolume() {
    return ++volume;
}

double increaseVolume() {
    return ++volume;
}
```

The return type cannot be used to differentiate overloaded methods

```
error: method increaseVolume()
is already defined in class
Television
```

Method chaining

```
class Television {
    String model;
    boolean on;
    int channel;
    int volume;

    Television(String model) {
        this.model = model;
    }

    Television setVolume(int volume) {
        this.volume = volume;
        return this;
    }

    Television turnOn() {
        on = true;
        return this;
    }

    Television turnOff() {
        on = false;
        return this;
    }

    Television setChannel(int channel) {
        this.channel = channel;
        return this;
    }
}
```

Using method chaining we can concatenate method invocations as in

```
new Television("ES213“).turnOn()
     .setChannel(501).setVolume(16)
     .turnOff();
```

Methods with variable number of arguments

A variable length argument list is specified with three periods

```
int add(int... values) {
  int summation = 0;
  for (int i = 0; i < values.length; i++) {
       summation += values[i];
  }
  return summation;
}
```

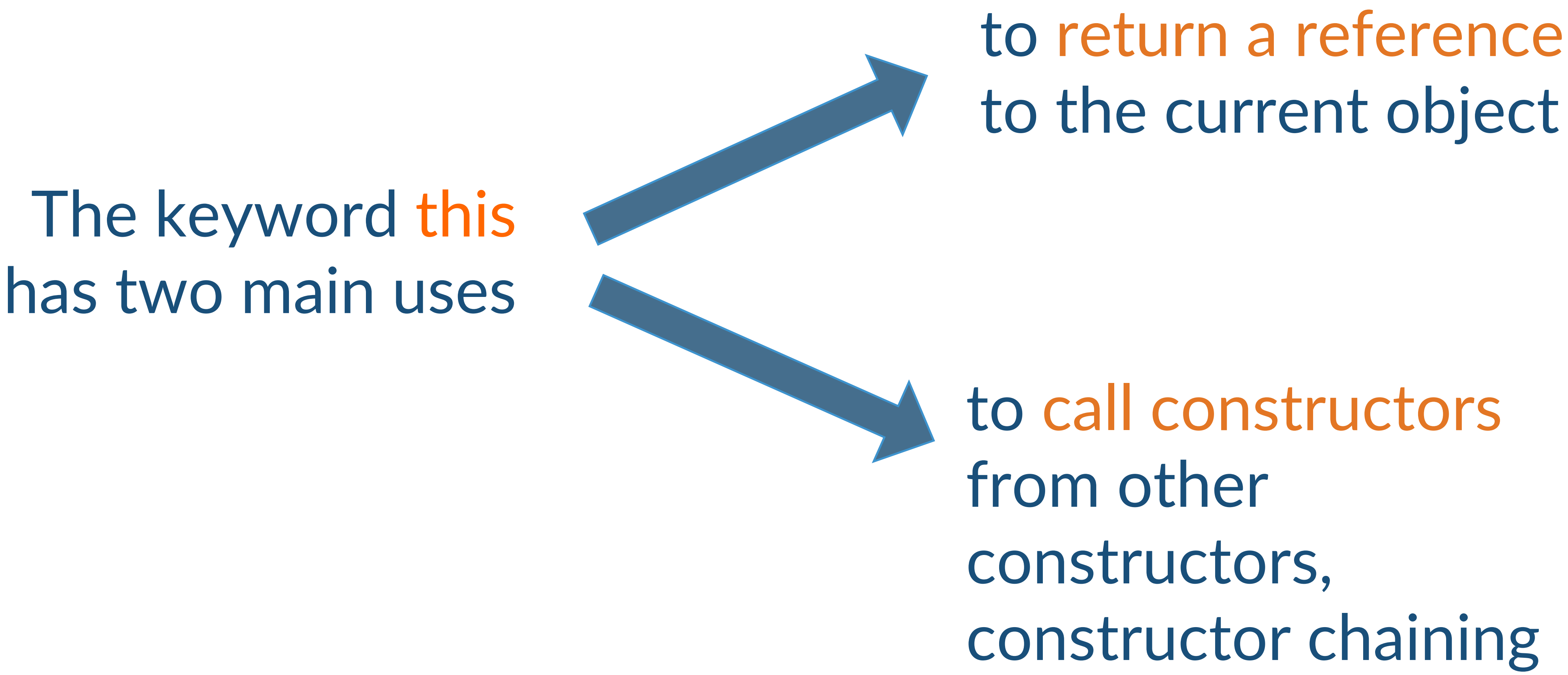
```
int sum = add(1, 2, 3, 4, 5);
int sum = add(new int[] {1, 2, 3, 4, 5});
```

The argument is implicitly declared as an array, however, the function can be called with a variable number of arguments

Is this overloading legal?

```
int add(int... args) {
    …
}

int add(int[] args) {
     …
}
```

The keyword “this”



The keyword this
has two main uses

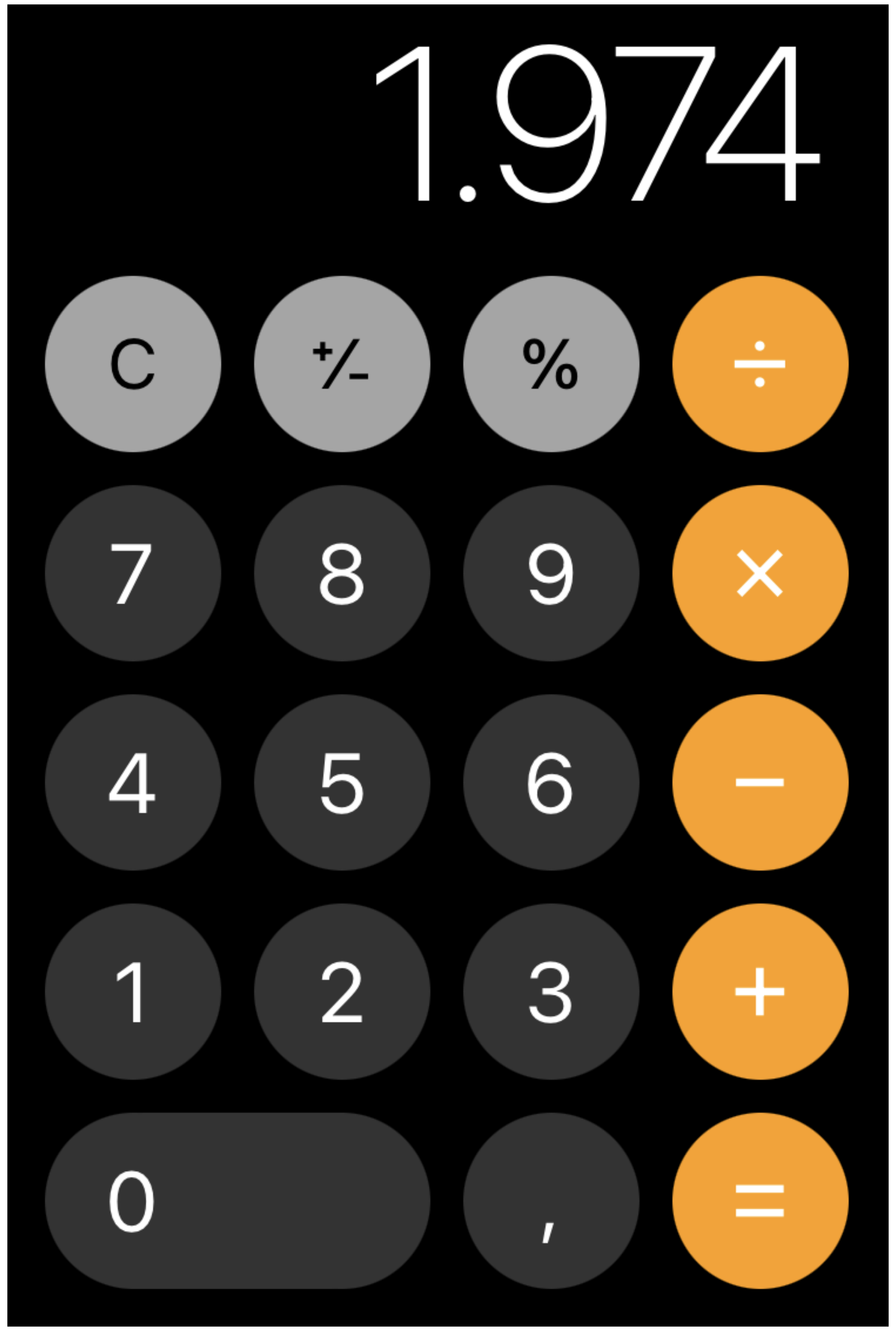
to return a reference
to the current object

to call constructors
from other
constructors,
constructor chaining

It has also other uses that we’ll discover later

Assignment

Assignment



Define a calculator class that

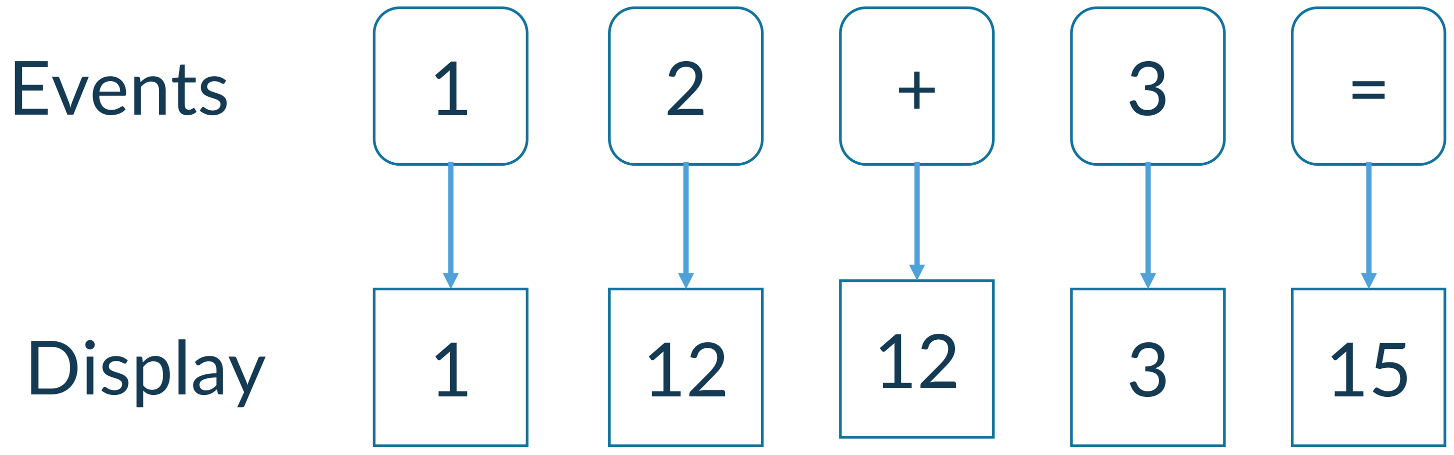
1. receives “events” from a calculator keyboard
2. sends the output to a Display object

```
class Display {
    void display(String text) {
        System.out.println(text);
    }
}
```

```
class Calculator {

    final Display display;
    //...

    Calculator(Display display) {
        this.display = display;
    }

    void plusPressed() {
        //...
    }

    void zeroPressed() {
        //...
    }

    //...
}
```

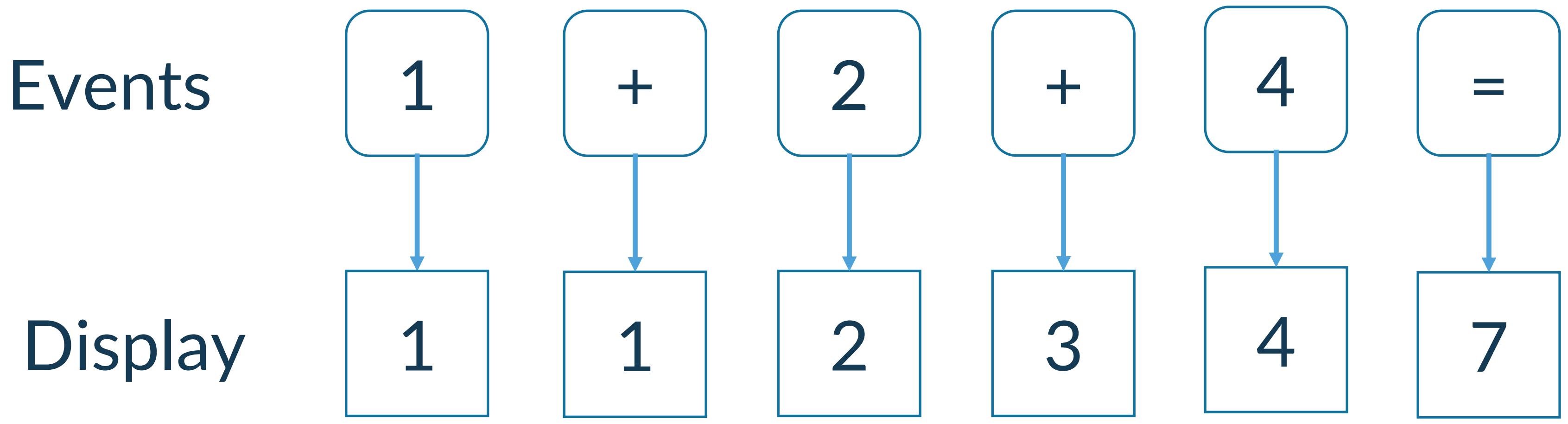
A couple of scenarios

Sample scenario



Events	1	2	+	3	=
Display	1	12	12	3	15

Operations chaining

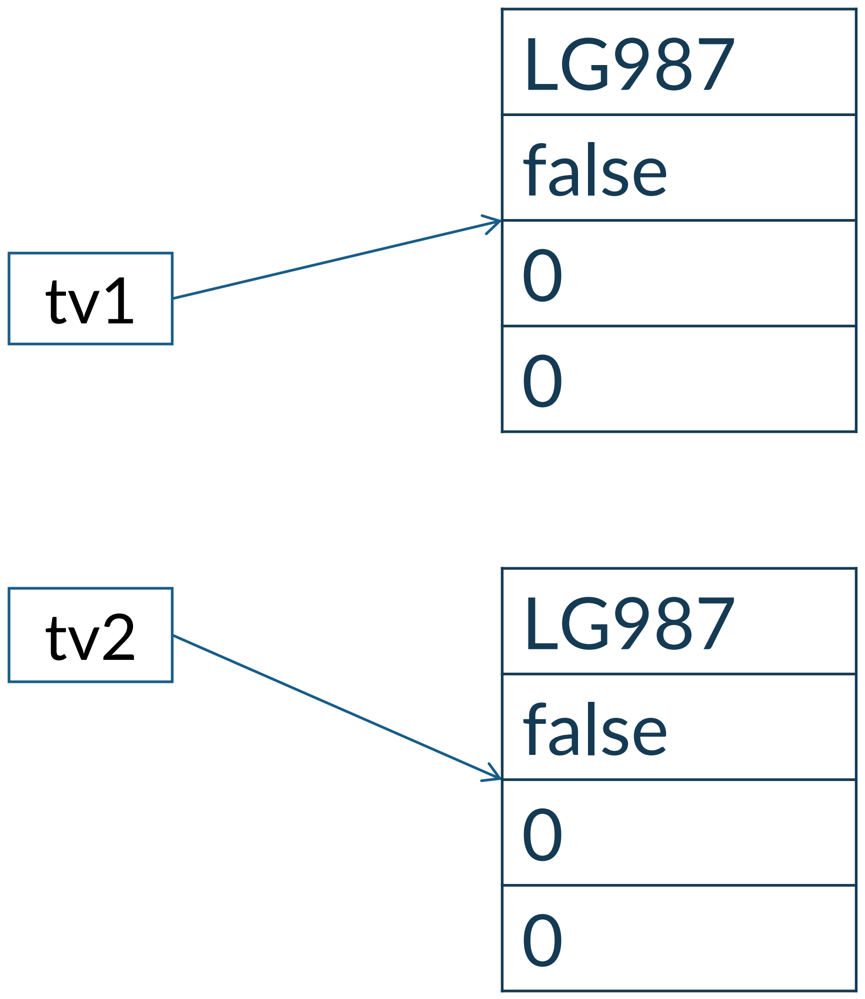


Events	1	+	2	+	4	=
Display	1	1	2	3	4	7

Referential equality

Referential equality 1/2

```
public static void main(String[] args) {
    Television tv1 = new Television("LG987");
    Television tv2 = new Television("LG987");

    if (tv1 == tv2) {
        System.out.println("Same");
    } else {
        System.out.println("Different");
    }
}
```



tv1

LG987
false
0
0

tv2

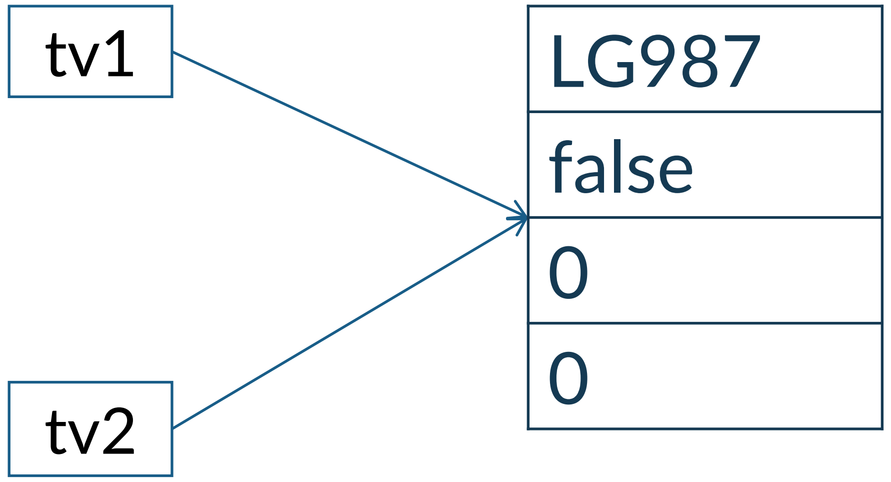
LG987
false
0
0

```
$ java Television
Different
```

tv1 and tv2 are references
to different objects

Referential equality 2/2

```java
public static void main(String[] args) {
    Television tv1 = new Television("LG987");
    Television tv2 = tv1;

    if (tv1 == tv2) {
        System.out.println("Same");
    } else {
        System.out.println("Different");
    }
}
```



```
$ java Television
Same
```

tv1 and tv2 are references to the same object

Static members

Static members

HelloWorld.java

```java
public class HelloWorld {

    public static void main(String[] args) {
       System.out.println("Hello world!");
    }
}
```

Instance members (variables and methods) come to existence only when we create objects of their classes

On the contrary, when a member is declared static, it is a class member and it can be accessed without any reference to objects of its class

The keyword static must precede the member declaration

We have already met the main method that is declared static because it must be called before any object exists

Static variables

Variables declared as static are a sort of global variables

When objects of its class are declared, no copy of a static variable is made. Instead, all instances of the class share the same static variable

Fields that are both static and final can be used as global constants

```java
class Television {

    static int numberOfTelevisionsTurnedOn;

    String model;
    boolean on;
    int channel, volume;

    Television(String model) {
        this.model = model;
    }

    void turnOn() {
        on = true;
        numberOfTelevisionsTurnedOn++;
    }

    void turnOff() {
        on = false;
        numberOfTelevisionsTurnedOn--;
    }
}
```

Static method restrictions 1/3

Static methods can only directly invoke other static methods, they cannot invoke instance methods if they haven't a reference to an object

```
class Television {

    int volume;

    static Television increaseVolumeBy5() {
        increaseVolume(5);
    }

    Television increaseVolume(int delta) {
        volume += delta;
    }
}
```

```
error: Non-static method
‘increaseVolume(int)’ cannot be referenced
from a static context
```

```
class Television {

    int volume;

    static void increaseVolumeBy5(Television tv) {
        tv.increaseVolume(5);
    }

    int increaseVolume(int delta) {
        return volume += delta;
    }
}
```

Static method restrictions 2/3

Static methods can only directly access static variable, they cannot access instance variables if they haven’t a reference to an object

```
class Television {

    int volume;

    static Television increaseVolumeBy5() {
        volume += 5;
    }

    Television increaseVolume(int delta) {
        volume += delta;
    }
}
```

```
class Television {

    int volume;

    static void increaseVolumeBy5(Television tv) {
        tv.volume += 5;
    }

    int increaseVolume(int delta) {
        return volume += delta;
    }
}
```

```
error: Non-static field ‘volume’ cannot be
referenced from a static context
```

Static method restrictions 3/3

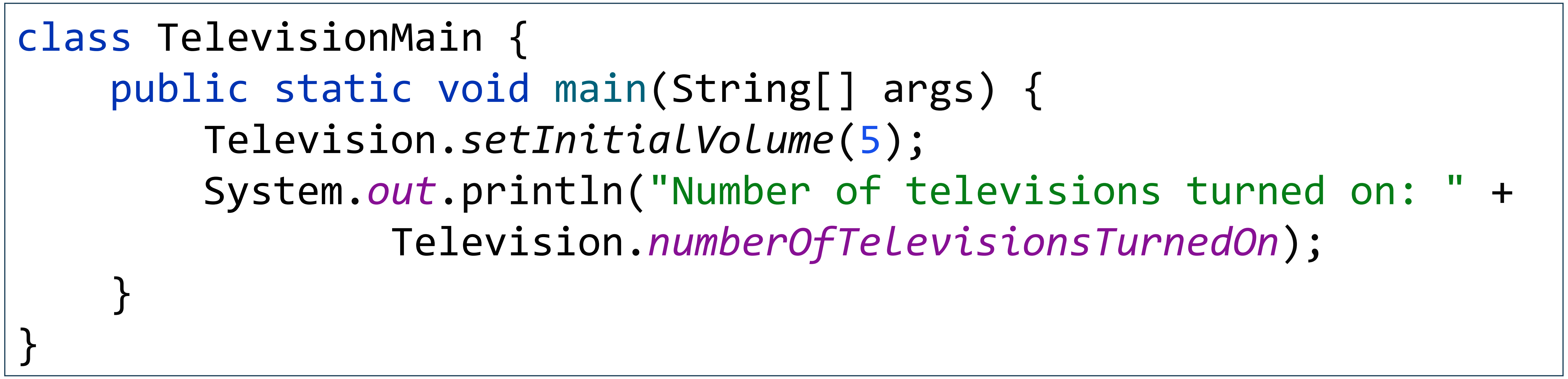
Static methods cannot refer to this in any way

```
class Television {

    int volume;

    static Television increaseVolumeBy5() {
        this.volume += 5;
    }

    Television increaseVolume(int delta) {
        volume += delta;
    }
}
```

```
class Television {

    int volume;

    static void increaseVolumeBy5() {
        this.increaseVolume(5);
    }

    int increaseVolume(int delta) {
        return volume += delta;
    }
}
```

```
error: Television.this cannot be referenced from a static context
```

Accessing static members



```
class TelevisionMain {
    public static void main(String[] args) {
        Television.setInitialVolume(5);
        System.out.println("Number of televisions turned on: " +
                Television.numberOfTelevisionsTurnedOn);
    }
}
```

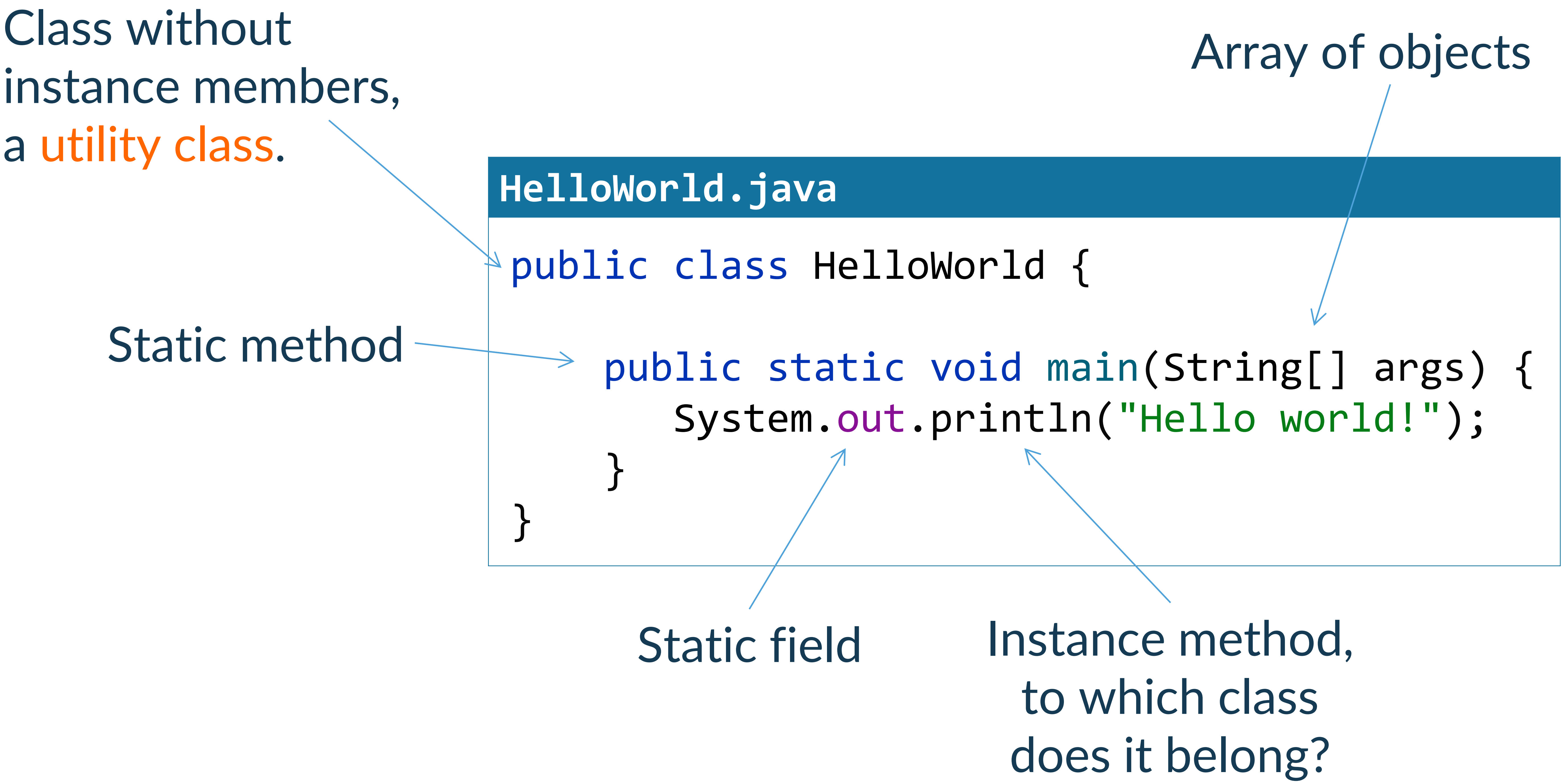
Outside of the class in which they are defined, static methods and static variables can be used independently of any object. To do so, you need only to specify the name of their class followed by the dot operator.

Resolving shadowing of static variables

```java
class Television {

    static int initialVol;

    int volume;

    static void setInitialVolume(int initialVol) {
        initialVol = initialVol;
    }

    Television() {
        volume = initialVolume;
    }

```

```java
class Television {

    static int initialVol;

    int volume;

    static void setInitialVolume(int initialVol) {
        Television.initialVol = initialVol;
    }

    Television() {
        volume = initialVolume;
    }

```

Revisiting Hello, World!



Class without instance members, a utility class.

Array of objects

HelloWorld.java

```java
public class HelloWorld {

    public static void main(String[] args) {
        System.out.println("Hello world!");
    }
}
```

Static method

Static field

Instance method, to which class does it belong?

https://docs.oracle.com/en/java/javase/17/docs/api/java.base/java/lang/System.html#out

Initialization and default values

Default values

TelevisionMain.java

```java
class Television {
    static int initialVol;
    String model;
    boolean on;
    int channel;
    int volume;
}

class TelevisionMain {
    public static void main(String[] args) {
        Television tv = new Television();
        System.out.println(tv.model);
        System.out.println(tv.on);
        System.out.println(tv.channel);
        System.out.println(tv.volume);
        System.out.println(Television.initialVol);
    }
}
```

All fields, both instance variables and class variables, are guaranteed to have an initial value when we create an object

Object references are initialized with the null reference, numeric variables with 0, boolean variables with false

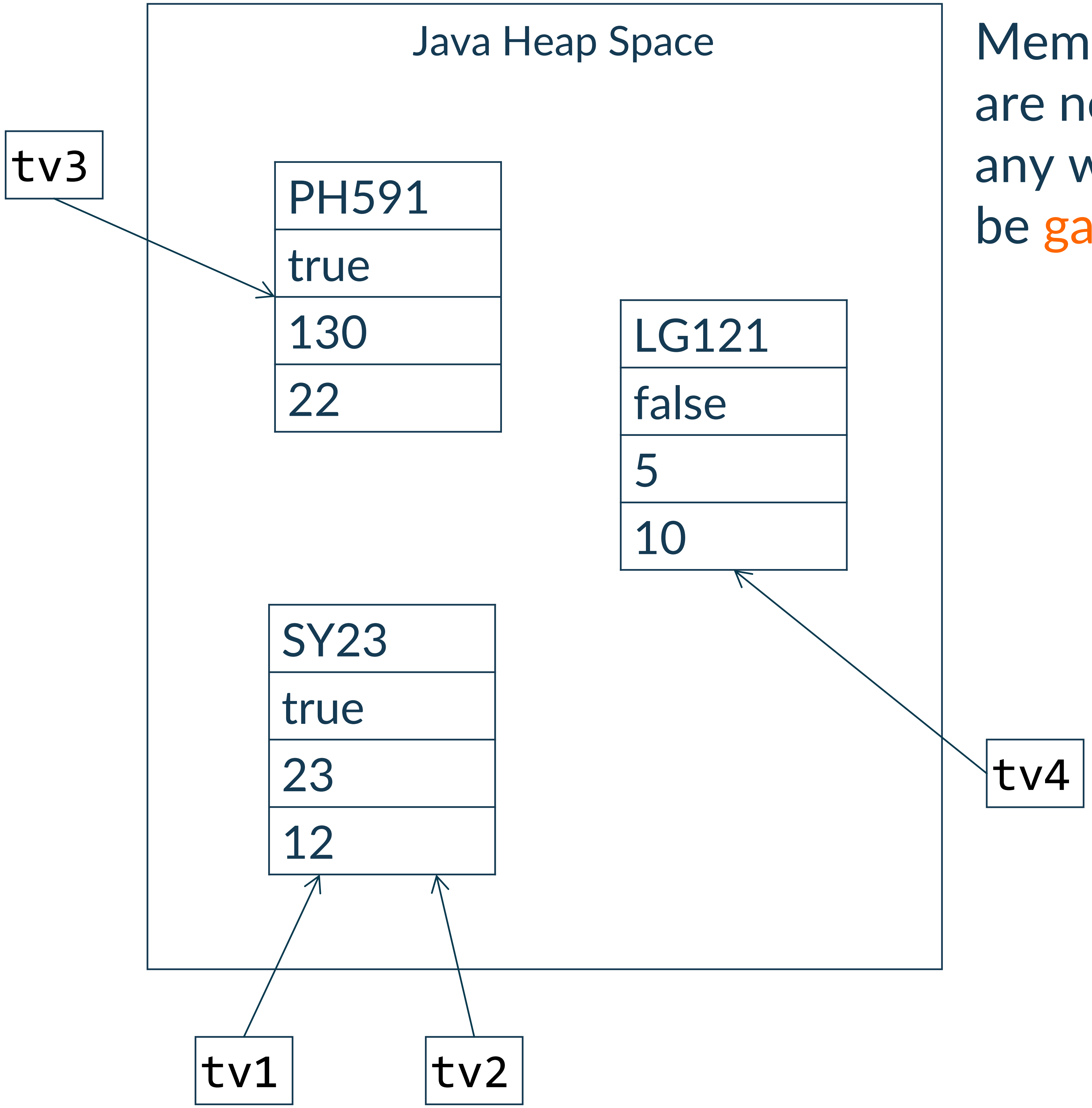
So, in principle we don’t need to initialize fields, we only need to initialize local variables before their use

```
$ java TelevisionMain.java
null
false
0
0
0
```

Garbage collection

A word about garbage collection

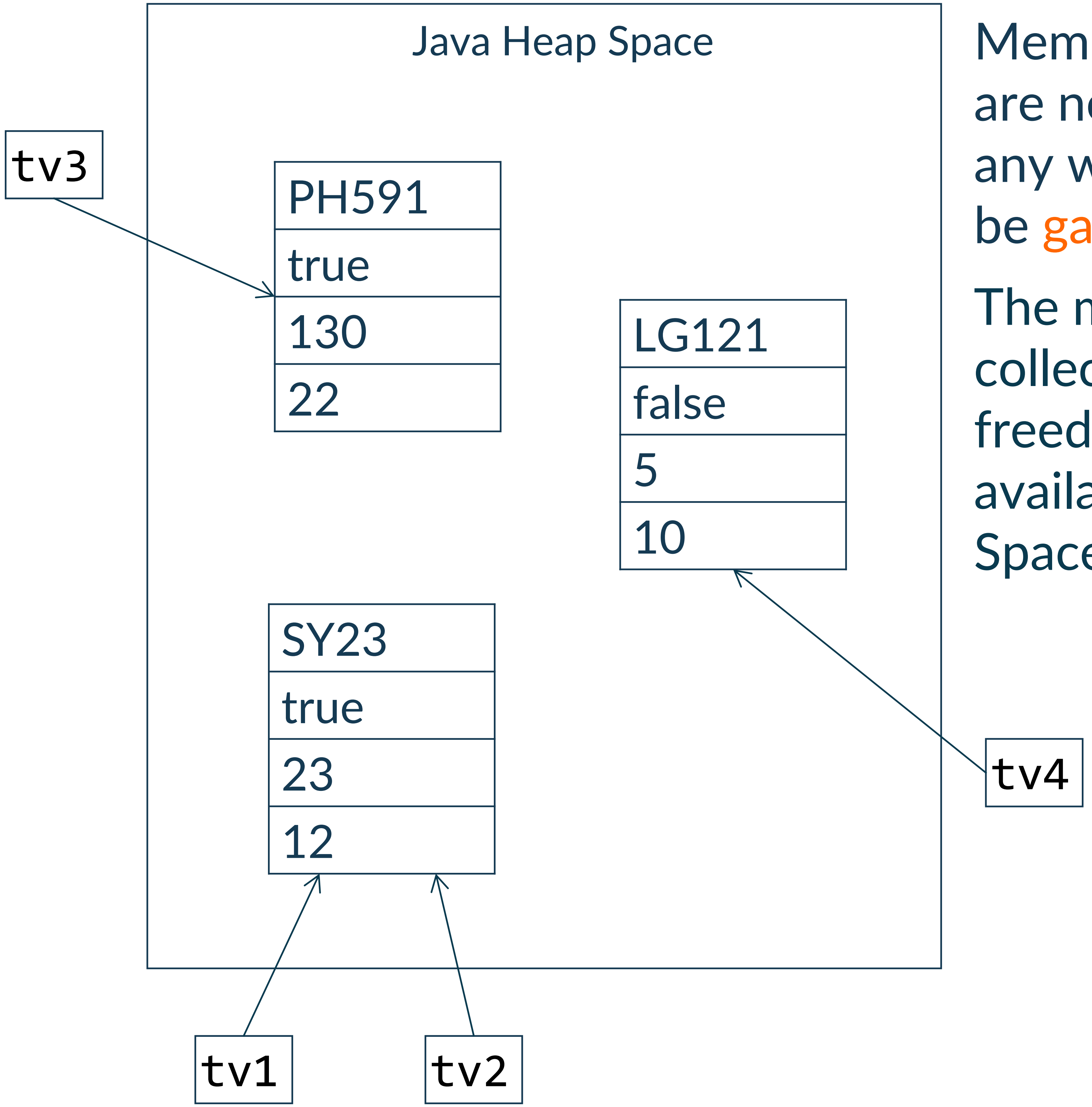
```
var tv1 = new Television();
tv1.model = "SY23"
tv1.on = true;
Television tv2 = tv1;
tv2.channel = 23;
tv2.volume = 12;

var tv3 = new Television();
tv3.model = "PH591"
tv3.on = true;
tv3.channel = 130;
tv3.volume = 22;

var tv4 = new Television();
tv4.model = "LG121"
tv4.on = false;
tv4.channel = 5;
tv4.volume = 10;
```



Memory locations that are not referenced in any way are eligible to be garbage collected

A word about garbage collection

```
var tv1 = new Television();
tv1.model = "SY23"
tv1.on = true;
Television tv2 = tv1;
tv2.channel = 23;
tv2.volume = 12;

var tv3 = new Television();
tv3.model = "PH591"
tv3.on = true;
tv3.channel = 130;
tv3.volume = 22;

var tv4 = new Television();
tv4.model = "LG121"
tv4.on = false;
tv4.channel = 5;
tv4.volume = 10;

tv4 = null;
```



Memory locations that are not referenced in any way are eligible to be garbage collected

The memory of garbage collected objects is freed and made again available in the Heap Space

Thank you!

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